

WATER QUALITY MONITORING REPORT
Lassen Creek, Willow Creek and Goose Lake

1993 - 1996

CA Regional Water Quality Control Board
Central Valley Region

I. BACKGROUND

In August 1992, the Goose Lake Resource Conservation District (RCD) received a Clean Water Act Section 319(h) grant to reduce nonpoint source water quality impairment and enhance instream beneficial uses in Lassen and Willow Creeks. Willow and Lassen Creeks are tributary to Goose Lake in northeast California and Oregon. The 319(h) project was carried out in support of a joint California-Oregon effort, called the Goose Lake Fishes Working Group, to protect and restore native fish populations in the Goose Lake basin.

In cooperation with the Willow/Lassen Creek 319(h) project and the Goose Lake Fishes Group, a water quality monitoring program was conducted seasonally from 1993 through 1996. Contributors included the California Regional Water Quality Control Board, U.S. Fish and Wildlife Service, Modoc National Forest and the Goose Lake RCD. The purpose of the monitoring program was to:

1. Determine existing water quality conditions in Willow Creek, Lassen Creek and Goose Lake.
2. Identify any water quality constraints to perpetuation of native fish populations and to other beneficial water uses.
3. Establish a baseline for assessing water quality trends following watershed protection and enhancement efforts.

II. MONITORING PROTOCOL

A. Willow and Lassen Creek Water Quality

The following water quality parameters were measured by RWQCB periodically during the summer months:

<u>Parameter</u>	<u>Method</u>
E.C.	- YSI Conductivity Meter
Dissolved Oxygen	- modified Winkler method
pH	- PHH-IX Omega Field probe
Stream Flow	- Swoffer Flow meter
Metals	- commercial laboratory
Bacteria	- commercial laboratory

In 1996, temperature, pH, E.C. and DO were measured using a Hydrolab Multi parameter Water Quality Data Recorder.

B. Goose Lake Water Quality

Water quality parameters were measured in 1993 by USFWS and subsequently in 1995 and 1996 by the RWQCB using a Hydrolab unit. Sample station locations were fixed using GPS equipment.

C. Temperature Monitoring

Daily maximum and minimum temperatures were measured using recording thermograph (Hobo Temperature Recorders) at four locations on Willow Creek by the RCD and at several locations on Lassen and Cold Creek by the Modoc National Forest. In summer, 1995, temperatures were also recorded at the GL-2 station in Goose Lake.

III. RESULTS AND DISCUSSION

A. Willow and Lassen Creek Water Quality

General Parameters - Water quality sample locations on Willow and Lassen Creeks are shown on Figure 1. Sample results are shown in Table 1. Dissolved oxygen, pH, and conductivity appear to be in the expected range for eastern California streams and none of these parameters appear limiting to aquatic life. Dissolved minerals (as indicated by E.C.) are higher in Willow Creek and, for both streams, E.C. approximately doubled from the upstream to the downstream station. This is probably due to the combined effect of land use practices and natural mineralization that occurs as streams transcend from their headwaters to the valley floor.

Standard Minerals - Results of analysis for standard minerals are shown in Table 2. Most constituents show increase from the upstream to the downstream station, however none of the constituent levels appear limiting for aquatic life or other beneficial uses.

Metals - Metal concentrations (copper, zinc and cadmium) were nondetectable or at levels safe for aquatic life (Table 3). The elevated concentrations at WC-2 in 1993, which were reported as total metals, are probably the result of metals attached to soil particles and included with the suspended sediment in the water column.

Bacteria - Coliform bacteria were sampled only once and the reported levels (Table 4) are high relative to standards for water contact use. Additional samples will be needed to assess overall water quality conditions with respect to bacteria.

Flow - Stream flow was measured at each Willow and Lassen Creek station during water quality sampling and results are shown in Table 1. Mid and late summer stream flow was substantially reduced in both streams from the upstream to the downstream stations.

Stream flow impacts water temperature and other water quality parameters and is an important variable in the determination of available aquatic habitat. During the 1960's, stream flow was gauged on Lassen Creek near Highway 395 and at Willow Creek approximately one mile upstream of Highway 395. Previous flow data is compared to current data as follows:

	Sept. Average 1961-1978 (cfs)	Sept. Average 1993-1996 (cfs)
Lassen Creek	1.60	0.42
Willow Creek	0.36	0.09
Average Annual ^a precipitation	--- ^b	16.5

^a historic annual average precipitation is approximately 14 inches

^b data unavailable

The data appear to indicate that current late summer flows in lower Willow and Lassen Creeks have decreased relative to flows in the 1960s and 70s. It should be noted however, that the current flow measurements were taken at a point downstream of the past records and could be influenced by water diversions from the stream reach between the two monitoring locations.

Temperature - Temperature recorder locations for Lassen Creek and Willow Creek are shown on Figure 2 and results are summarized in Tables 5 and 6 (complete temperature records are shown in Appendix A).

Tables 5 and 6 are an attempt to summarize the temperature data for Lassen and Willow Creeks in a manner which provides information on the following questions:

- 1) How do stream temperatures compare with known tolerance limits of sensitive species (in this case red band trout)?
- 2) Do stream temperatures show significant differences or trends between stations?
- 3) Do stream temperatures collectively or at individual stations show a warming or cooling trend over time?

Regarding question number one, there are no specific studies on the temperature tolerance of Goose Lake Redband Trout. EPA Water Quality Criteria specifies the following short-term maximum temperature limits for rainbow trout:

Adult/juvenile survival	-	75°F
Adult/juvenile growth	-	66°F
Embryo survival	-	55°F
Spawning	-	48°F

Examination of the four day maximum temperatures in Tables 5 and 6 show that temperatures of some portions of Lassen and Willow Creeks do reach very high levels relative to other streams known to support cold water fish species.

To fully understand the impacts of Lassen and Willow Creek temperatures on Red Band Trout distribution and survival, more information would be needed on spawning and rearing habits, and on the actual tolerance limits of the various life stages of this species. For purposes of the Goose Lake Fishes program, it should be assumed that high temperature in streams is an important limiting factor and that projects which contribute to lower

water temperatures (i.e., projects which increase shade canopy, improve channel morphology and/or increase stream flows) will benefit the species.

Tables 5 and 6 also show average monthly maximum and average diurnal change for individual stations on Lassen and Willow Creeks. This information provides a means of comparing temperature conditions between monitoring stations and between stream reaches.

For Lassen Creek stream temperatures generally increased from the upstream to the downstream stations. The stream reach showing the highest rate of temperature increase was between Station 1 (Upper Springs) and Station 3 (below Harris Flat). The average diurnal change at Station 3 was also high relative to the other temperature stations.

At Willow Creek, the highest recorded temperatures were at Station 1 (Fandango Valley). Temperatures were cooler downstream at Station 3, probably in part due to the influence of Bucks Creek. Temperatures increased again at Station 4 (Highway 395) but were still below levels recorded at Station 1. Average diurnal change was highest at Station 1.

Relatively high temperature maximums and diurnal change near Harris Flat on Lassen Creek and at Fandango Valley Willow Creek are probably in part the result of lower flow at these upstream locations which allows for increased temperature fluctuation. However, the data does seem to indicate that stream temperature conditions could benefit from improved shade canopy and/or channel morphology in these reaches.

Regarding the question of long-term temperature trends, more time and data are required to interpret possible changes in overall temperature regimes of Willow and Lassen Creeks. Comparison of seasonal temperature patterns from one year to another must consider two important variables - air temperature and flow.

To assist in future efforts to evaluate stream temperature trends, climatological data (air temperature, precipitation, and flow) are summarized in Table 7. In general, summer 1993 can be characterized as wetter and cooler than normal, summer 1994 as drier and hotter than normal and, summers 1995 and 96 as in between.

B. Goose Lake Water Quality

General Parameters - Goose Lake water quality monitoring stations are shown in Figure 3 and results of water quality parameters monitored for Goose Lake are contained in Table 8.

Temperature, E.C., TDS, dissolved oxygen and pH were measured at the Lake surface and bottom at each station. Maximum lake depth found during the study period was 5.7 feet in June, 1996. In general, there was little or no variation either between sample stations or between surface and bottom readings. However, some temperature stratification was noted with surface/bottom temperature differences of up to 7°F in as little as two feet of depth. Temperature stratification is probably established during calm conditions then rapidly dissipates as winds mix the shallow Lake waters. Though there are reports of springs in the vicinity of GL-2, 3, 4 and 5, this was not confirmed by the water quality monitoring results.

TDS concentrations have historically increased as lake levels decreased and this relationship was also evident during this study. Figure 4 shows the historic relationship between TDS concentration and lake surface elevation (from RWQCB 1967 Goose Lake Water Quality Data Report). Results from the 1993-96 monitoring have been added to the graph and show that the 1993-96 data were somewhat lower in TDS than previously reported for similar lake levels.

Standard Minerals - Results of tests for standard chemical constituents in Goose Lake are shown in Table 9 and compared with levels reported from 1904 to 1966. With the exception of iron, manganese and hardness, the 1993-96 results fall within the historic range.

Temperature - In summer, 1995, a temperature recorder was placed near the lake bottom at Station GL-2. Results of daily temperature readings are summarized in Table 10. In general, maximum lake temperatures were relatively low compared to tributary stream temperatures and diurnal temperature changes were also low. Based on results of temperatures recorded during Goose Lake water quality sampling (Table 8) and from the summer 1995 temperature recorder, there was no indication that maximum water temperatures in the Lake would be a critical limiting factor for Redband Trout or other aquatic species.

IV. SUMMARY CONCLUSIONS

A. Lassen and Willow Creek

1. With the exception of temperature, and possibly bacteria, measured water quality parameters (pH, conductivity, dissolved oxygen, nutrients, metals and standard minerals) were at levels which would not adversely impact aquatic life or other beneficial water uses and did not exceed Regional Board Basin Plan standards.
2. Temperatures periodically exceeded tolerance limits for salmonid species, as published in national water quality criteria. Specific tolerance limits for Goose Lake Redband Trout are unknown and Redband Trout were observed in the streams throughout the study period.
3. Stream temperatures in Lassen Creek near Harris Flat and in Willow Creek at Fandango Valley showed the highest rate of temperature increase and the highest diurnal fluctuation. Efforts to improve stream channel and habitat conditions should include these stream reaches.
4. Late summer stream flow was substantially reduced in lower Willow and Lassen Creek even in above normal rainfall years.
5. Efforts to protect or improve water quality conditions should focus on stream temperature and stream flow enhancement.

B. Goose Lake

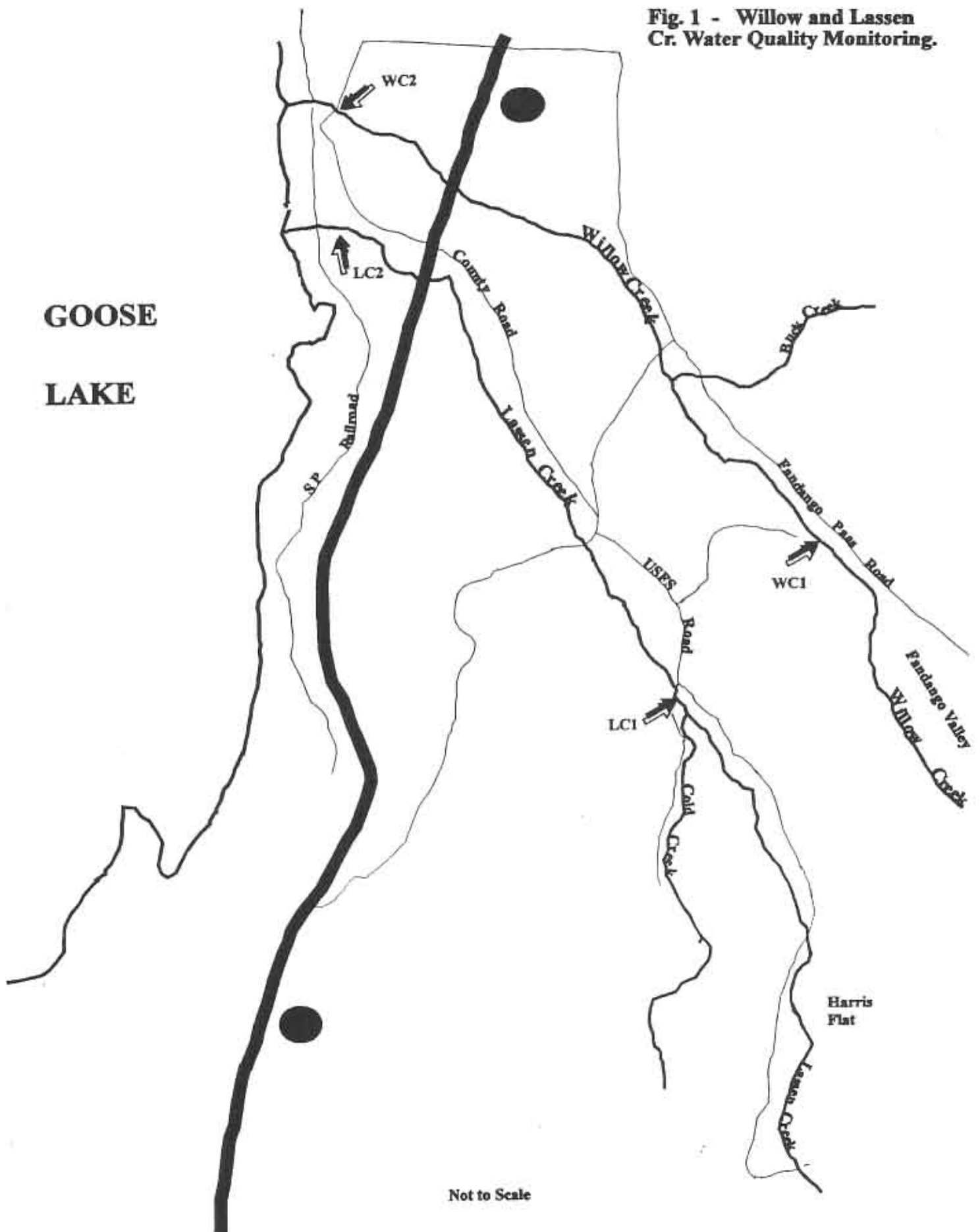
1. Water quality parameters were in the range of concentrations reported historically for Goose Lake and were not in excess of levels thought to be limiting to native aquatic species.
2. Temperature maximum and diurnal fluctuation was low relative to conditions in tributary streams.

3. Lake salinity (as measured by TDS) was somewhat lower than concentrations reported historically for similar lake levels.

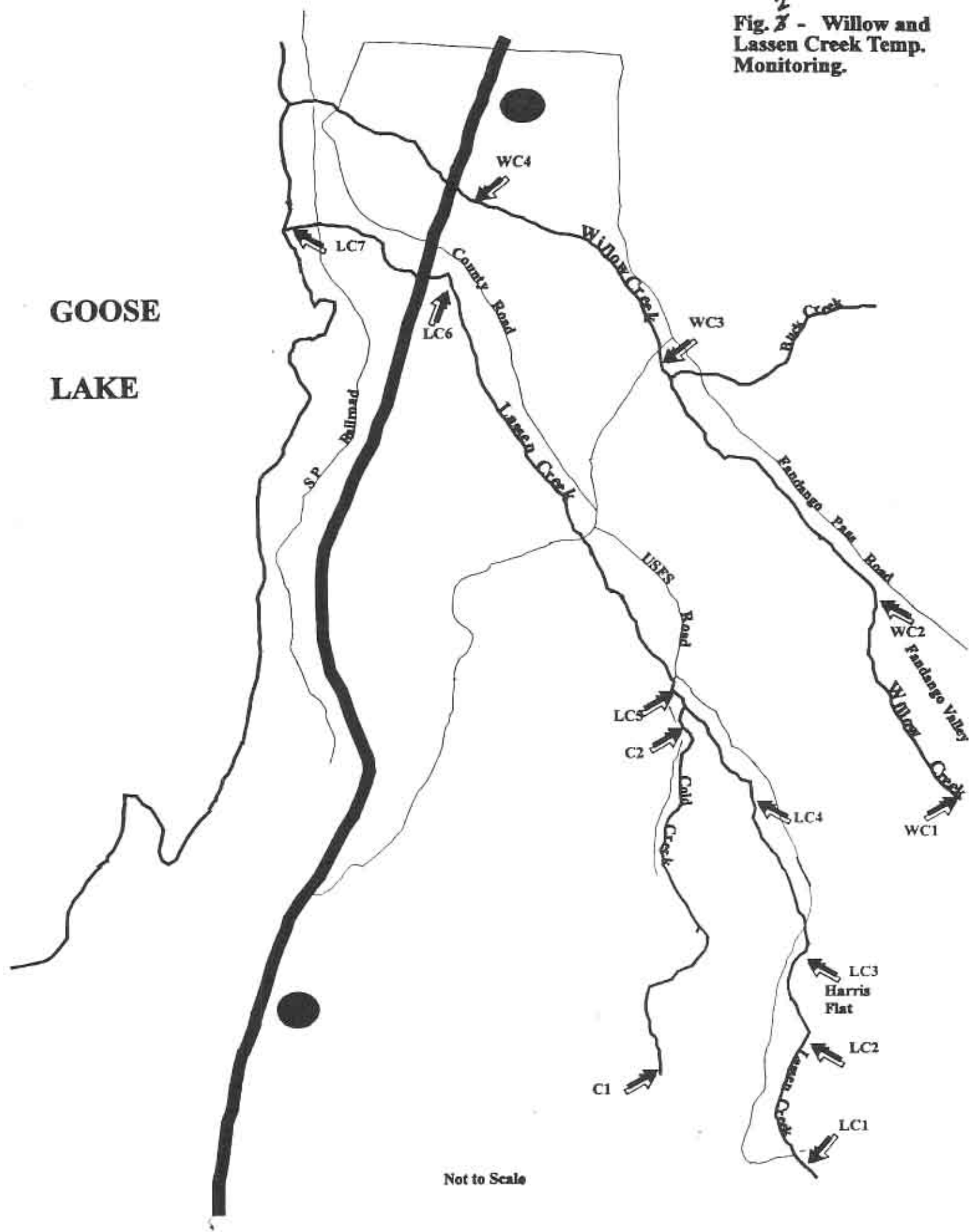
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FIGURES

**Fig. 1 - Willow and Lassen
Cr. Water Quality Monitoring.**



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**Fig. 3 - Willow and
 Lassen Creek Temp.
 Monitoring.**



Not to Scale

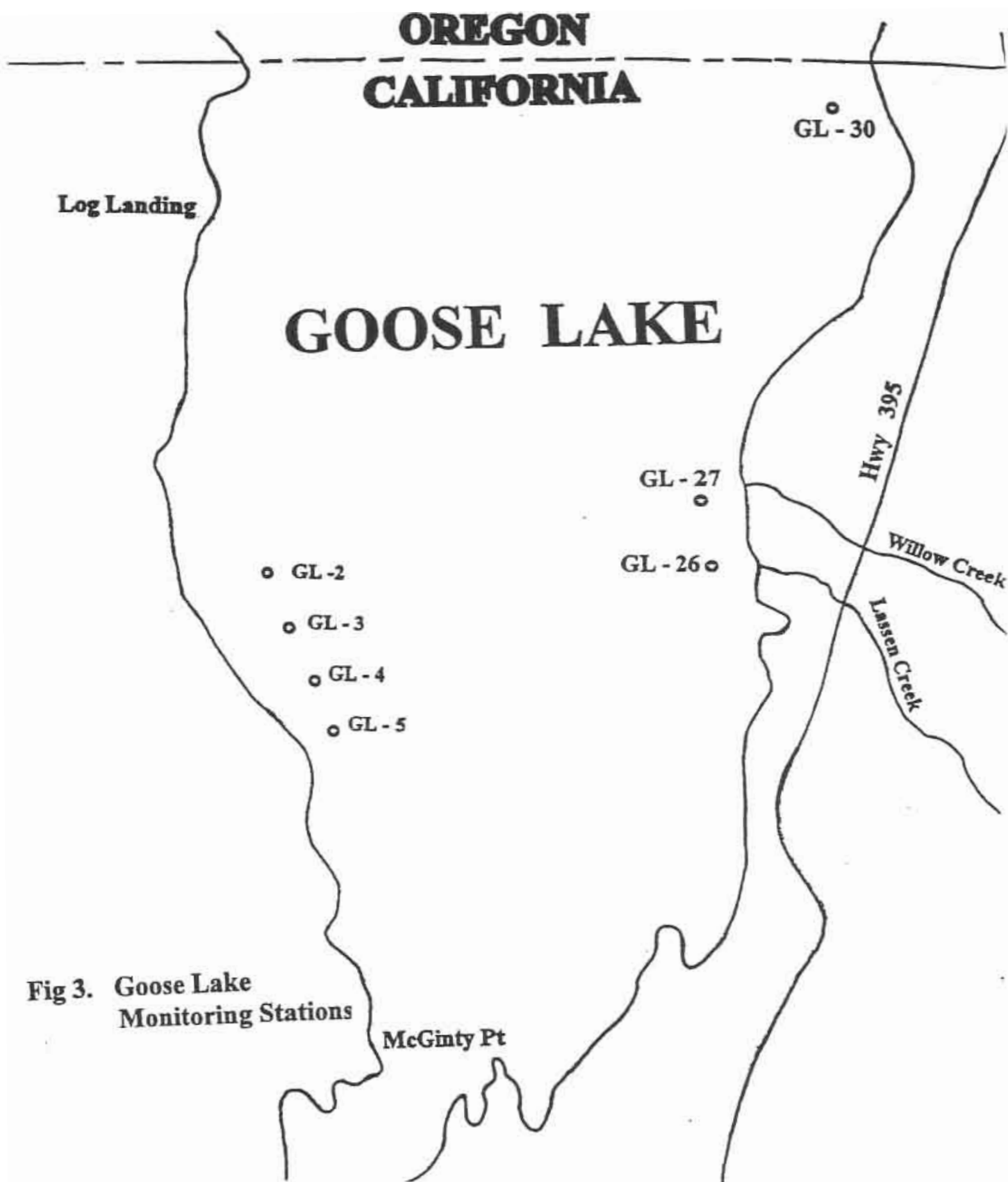
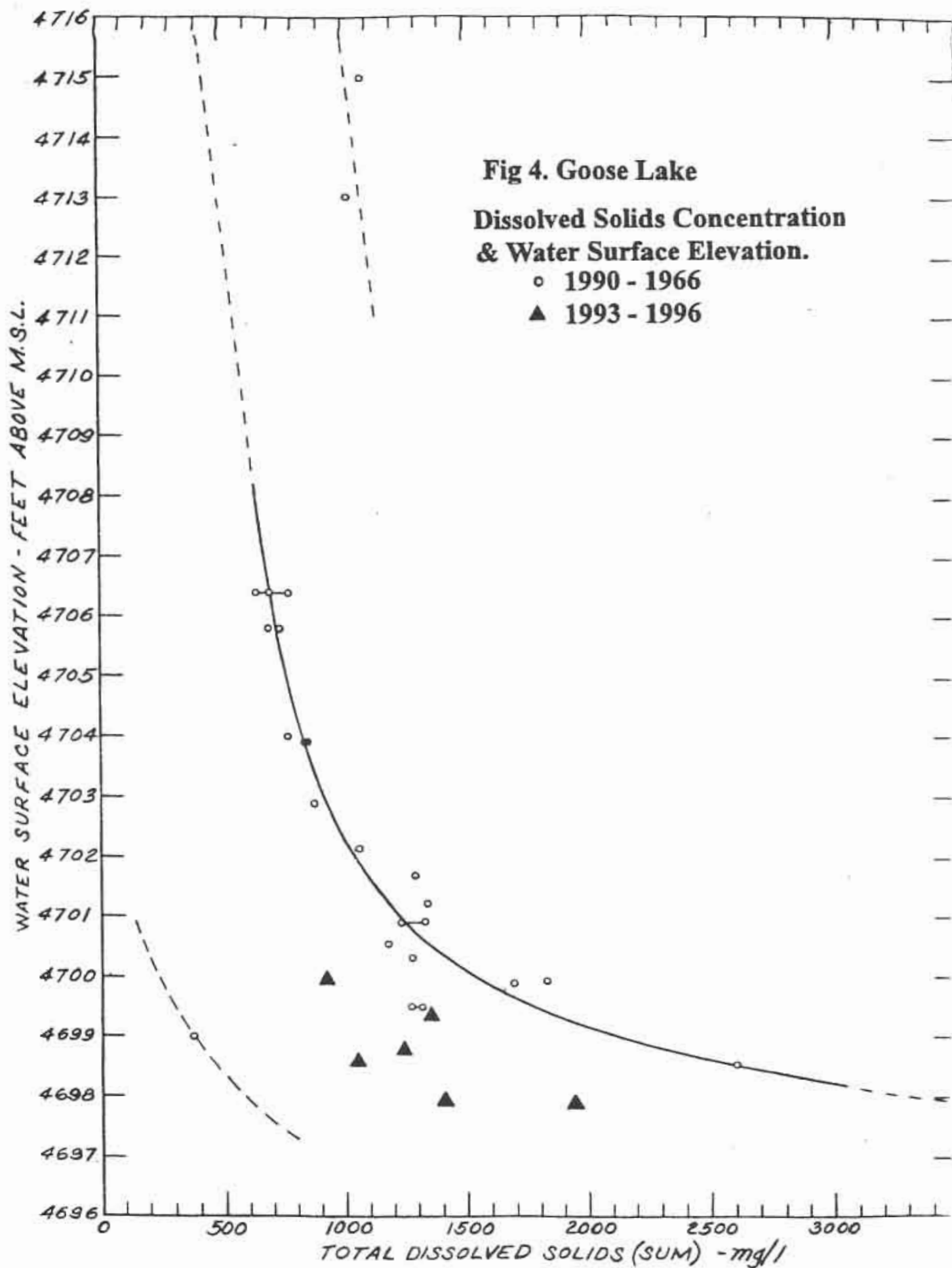


Fig 3. Goose Lake
Monitoring Stations



TABLES

Table 1. Lassen and Willow Creek Water Quality Data

Willow Creek							
Date	Station	Time	Flow (cfs)	Temp. (F)	EC (umhos)	DO (mg/l)	pH
16-Sep-93	WC - 1	1023	0.18	49	100	9.5	8.7
16-Sep-93	WC - 2	1130	0.08	57	225	11	8.5
10-Aug-94	WC - 1	1240	0.25	66	155	8.3	8.2
10-Aug-94	WC - 2	1400	0.003	80	450	10	8.2
19-Jul-95	WC - 1	1510	1.9	74	138	9.3	8.8
19-Jul-95	WC - 2	1340	1.7	85	155	14	8.7
27-Sep-95	WC - 1	1515	0.25	61	152	a	a
27-Sep-95	WC - 2	1610	0.19	65	210	a	a
13-Jun-96	WC - 2	1445	1.75	81	166	7.9	8.5
27-Sep-96	WC - 1	1435	0.16	59	217	9	8.5
27-Sep-96	WC - 2	1317	0.1	64	309	10.7	8.8
Lassen Creek							
Date	Station	Time	Flow (cfs)	Temp. (F)	EC (umhos)	DO (mg/l)	pH
16-Sep-93	LC - 1	1730	1.63	60	58	7.5	8.5
16-Sep-93	LC - 2	1230	0.72	56	100	9.3	8.1
10-Aug-94	LC - 1	1025	2.5	53	70	8.5	7.8
10-Aug-94	LC - 2	1500	0.25	80	150	6.8	7.0
19-Jul-95	LC - 1	1420	8.5	66	40	9.6	8.1
19-Jul-95	LC - 2	1300	5.93	68	62	9.1	7.6
27-Sep-95	LC - 1	1450	1.64	59	48	a	a
27-Sep-95	LC - 2	1630	0.32	60	80	a	a
13-Jun-96	LC - 2	1530	8.9	70	69	7.3	7.0
27-Sep-96	LC - 1	1400	1.56	56	70	9.5	8.0
27-Sep-96	LC - 2	1240	0.4	57	124	9.9	7.3

(a) No data available

Table 2. Lassen and Willow Creek Standard Minerals (a)

Constituents	Units	LC - 1	LC - 2	WC - 1	WC - 2
Calcium	mg/l	5.2	10.6	14.75	21.9
Magnesium	mg/l	2.35	3.5	5.6	8
Sodium	mg/l	8.6	7.67	26.8	51
Potassium	mg/l	2.9	8.1	4.3	9.9
Iron	mg/l	0.22	0.74	0.16	0.16
Manganese	mg/l	0.009	0.022	0.013	0.019
Bicarbonate	mg/l	52	66	140	221
Carbonate	mg/l	ND	ND	ND	0.5
Chloride	mg/l	2	2.44	3.5	12.4
Flouride	mg/l	ND	ND	0.06	0.43
Boron	mg/l		0.014		0.092
Nitrate@N	mg/l	ND	ND	0.03	0.02
Ortho Phosphate@P	mg/l	0.075	0.09	0.145	0.1
Ammonia	mg/l	0.7	0.7	0.4	0.2
Sulphate	mg/l	ND	3.56	ND	3.49
Hardness	mg/l	26.5	45	62.5	84
Total Diss. Solids	mg/l	82.5	106	161	228

(a) Avg of three samples taken on 8/10/94, 9/27/95, and 6/13/96.

Table 3. Lassen and Willow Creek Metals				
Date	Station	Copper	Zinc	Cadmium
		(mg/l)	(mg/l)	(mg/l)
16-Sep-93	WC - 1	ND	ND	ND
16-Sep-93	WC - 2	0.015	0.027	nd
16-Sep-93	LC - 1	ND	ND	ND
16-Sep-93	LC - 2	ND	ND	ND
13-Jun-96	WC - 2	0.0014	ND	
13-Jun-96	LC - 2	0.0035	0.01	

ND - Non Detectable

Table 4. Lassen Creek, Willow Creek and Goose Lake Bacteria			
Date	Station	Total Coli	Fecal Coli
		mpn/100ml	mpn/100ml
13-Jun-96	WC - 2A	>1600	1600
13-Jun-96	WC - 2B	1600	900
13-Jun-96	LC - 2A	>1600	1600
13-Jun-96	LC - 2B	0.16	900
13-Jun-96	GL - 2A	500	<2
13-Jun-96	GL - 2B	500	<2

Table 5. Lassen Creek Temperature Monitoring

Year	Station #	July			August		
		4-Day Max	Avg Max	Avg Dirunal	4-Day Max	Avg Max	Avg Dirunal
		Temp(F)	Temp(F)	Change(F)	Temp(F)	Temp(F)	Change(F)
1993	4	68,65,64,67	64	15	71,71,71,70	64	12
1993	5	66,66,68,69	63	13	71,71,71,69	64	13
1993	6	59,59,60,64	57	15	68,66,66,64	58	19
1993	7	68,67,68,69	65	12	72,73,72,71	65	12
1994	1	62,61,62,61	61	14	62,62,62,62	61	16
1994	4	79,78,79,78	78	16	79,78,78,78	76	22
1994	5	72,79,79,78	76	18	76,75,75,76	72	20
1994	6	72,83,83,82	79	16	80,79,79,79	73	19
1995	1	52,52,52,53	51	10	53,54,54,54	53	13
1995	3	70,70,71,73	69	23	73,73,74,74	70	22
1995	4	70,67,69,66	66	14			
1995	5	76,76,76,76	73	15	77,78,79,79	73	21
1995	6	74,75,74,74	72	15	75,75,76,76	70	16
1996	1	54,56,55,56	54	12	55,55,57,56	55	13
1996	3	87,86,87,84	74	33	88,88,87,85	80	14
1996	5	76,76,77,77	74	15	74,73,72,72	70	14
1996	6				78,80,77,77	77	28

Station #**Location**

- 1 Upper Spring
- 2 Above Harris Flat
- 3 Below Harris Flat
- 4 Above Cold Creek
- 5 Below Cold Creek
- 6 Highway 395
- 7 At Goose Lake

Table 6. Willow Creek Temperature Monitoring													
Year	Station #	June				July				August			
		4-Day Max Temp(F)	Avg Max Temp(F)	Avg Dirunal Change(F)	4-Day Max Temp(F)	Avg Max Temp(F)	Avg Dirunal Change(F)	4-Day Max Temp(F)	Avg Max Temp(F)	4-Day Max Temp(F)	Avg Max Temp(F)	Avg Dirunal Change(F)	
1993	1							73,68,71,72	68			9	
1993	2							74,73,73,73	67			7	
1993	3							80,82,81,81	73			9	
1993	4							78,78,78,77	67			11	
1994	1	87,89,88,87	85										
1994	2	78,80,80,79	76	35	90,90,89,88	87		32	87,84,85,85	82		33	
1994	3	74,78,78,77	72	22	84,84,84,85	79		21	83,81,81,81	79		22	
1994	4	81,83,83,82	75	21	82,81,81,81	76		21	78,77,78,78	71		20	
				19	86,87,87,85	80		19	78,77,78,78	73		20	
1995	1	84,84,83,83	72										
1995	2	81,82,81,80	70	21	82,83,80,81	79	20						
1995	3	71,73,73,72	62	20	80,80,79,79	77		19	80,82,81,80	75		20	
1995	4	76,78,75,77	65	14	77,78,77,76	74		19	78,78,79,79	73		20	
				15	81,81,82,80	77		16	83,84,84,85	76		16	
1996	2	84,85,84,79	81										
1996	3	80,81,81,81	78	20	80,77,79,79	76	17						
				21	79,79,79,79	76	20						

Station # Location

- 1 Fandango Valley
- 2 Below Fandango Valley
- 3 Below Bucks Creek
- 4 Highway 395

Table 7. Climatological Data

Monthly Avg. Air Temperature (a)															
Month	1993			1994			1995			1996			1884 to 1990		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
June	69	54	61	76	43	60	68	45	57	71	47	59	74	43	59
July	75	44	60	90	54	72	81	50	68	87	55	69	84	49	67
August	79	46	62	87	44	66	82	44	63	86	55	70	83	47	65

Table 8. Goose Lake Water Quality								
Date	Station	Time	Depth (feet)	Temp (F)	EC (umhos)	TDS (mg/l)	DO (mg/l)	pH
30-Jun-93	GL - 2	1110	0	65	1953	1250	7.7	9
30-Jun-93	GL - 2	1110	3.6	63	1954	1251	7.6	9
30-Jun-93	GL - 3	1130	0	71	1942	1243	7.6	9
30-Jun-93	GL - 3	1130	2.1	64	1972	1262	7.6	9
30-Jun-93	GL - 4	1145	0	69	1945	1245	8	9
30-Jun-93	GL - 4	1145	3.3	62	1974	1263	7.6	9
30-Jun-93	GL - 5	1201	0	66	1972	1262	8.1	9
30-Jun-93	GL - 5	1201	2.7	62	1983	1269	7.8	9
08-Sep-93	GL - 2	1000	0	69	3049	1951	12.8	5
08-Sep-93	GL - 2	1000	2.4	67	3056	1956	9.2	9.5
08-Sep-93	GL - 3	1013	0	68	3124	1999	15	9.6
08-Sep-93	GL - 3	1013	0.9	68	3124	1999	15	9.6
08-Sep-93	GL - 4	1033	0	70	2995	1917	15	9.4
08-Sep-93	GL - 4	1033	2.1	67	3017	1931	10.1	9.4
08-Sep-93	GL - 5	1041	0	70	2996	1917	15	9.4
08-Sep-93	GL - 5	1041	1.5	68	3011	1927	13.5	9.4
19-Jul-95	GL - 2	920	0	68	1600	1024(c)	8.3	9.1
19-Jul-95	GL - 2	920	4	64	1490		8.2	9.1
19-Jul-95	GL - 3	945	0	68	1640		8.6	9.1
19-Jul-95	GL - 3	945	2	64	1610		8.6	9.1
19-Jul-95	GL - 4	1055	0	75	1810		8.9	9
19-Jul-95	GL - 4	1055	3.5	70	1860		9	9
19-Jul-95	GL - 5	1010	0	68	1700		8.8	9.1
19-Jul-95	GL - 5	1010	3	64	1690		8.8	9.1
27-Sep-95	GL - 2	1225	0	55	2200	1408(c)		
27-Sep-95	GL - 2	1225	2	54	2150		6.4	9.6
13-Jun-96	GL - 2	1126	0	68	1490	954(c)	6.3	8.7
13-Jun-96	GL - 2	1126	5.7	66	1474		6.1	8.7
13-Jun-96	GL - 4	1205	0	70	1520	972(c)	6.1	8.7
13-Jun-96	GL - 4	1205	5.3	66	1510		6	8.7
13-Jun-96	GL - 26	1315	0					
13-Jun-96	GL - 26	1315	3	63	1520		6.7	8.8
13-Jun-96	GL - 27	1325	0					
13-Jun-96	GL - 27	1325	4	63	1510		9.8	8.7
27-Sep-96	GL - 30	1030	0					
27-Sep-96	GL - 30	1030	3	56	2100	1370(c)	7.8	9.1

(c) Computed from EC value.

Table 9. Goose Lake Standard Minerals				
Avg of two samples 9/27/95 & 6/13/96			Historic Record (1904-1966)	
Constituents	Units	GL - 2	Max	Min
Calcium	mg/l	11.5	18	5
Magnesium	mg/l	9	13	2
Sodium	mg/l	567	970	160
Potassium	mg/l	64.5	65	27
Iron	mg/l	23.9	1.1	0.09
Manganese	mg/l	0.477	0.05	0
Bicarbonate	mg/l	816	796	400
Carbonate	mg/l	141	195	17
Chloride	mg/l	230	335	45
Flouride	mg/l	0.79	1	0.4
Boron	mg/l	3.26	4.8	2.1
Nitrate@N	mg/l	0.52	1.76	0.81
Ortho Phosphate@P	mg/l	0.81	3.9	0.4
Sulphate	mg/l	92.9	126	45
Hardness	mg/l	23	84	42
Total Diss. Solids	mg/l	1800	2600	640

Table 10. Goose Lake Temperature						
Station	Mo/Yr	Week	Max	Avg Max	Min	Avg Min
GL - 2	Jul/95	3	74.4	72.8	65.8	67.2
GL - 2	Jul/95	4	75.4	71.2	57.5	64.1
GL - 2	Aug/95	1	73.5	69.4	56.4	63.3
GL - 2	Aug/95	2	69.6	66.7	56.1	60.2
GL - 2	Aug/95	3	70.8	67.9	55.6	60.6
GL - 2	Aug/95	4	67.6	65.3	55.9	58.2
GL - 2	Sep/95	1	69.3	67.5	56.4	59.7
GL - 2	Sep/95	2	72	69.5	53.9	59.9